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SOME ELEMENTARY GUIDES FOR PERFORMING RESEARCH INTO THE EFFECTS OF PHYSIOTHERAPY TREATMENTS[1]

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If any profession is to survive, it cannot escape the necessity of continually subjecting its techniques to critical reappraisal. If a profession does not carry out research into its own methods, it is certain that it will come under challenge from other allied professions which do encourage research. This is already occurring with physiotherapy. In a recent International Seminar on Rehabilitation Medicine, Dr. J. V. Basmajian said:

> "I am persuaded that almost all therapeutic procedures in a rehabilitation department must be regarded as suspect; they may be either useless or harmful. I have little confidence in the scientific basis of any of them."

This is an extreme view, but it reflects the concern of many in the medical profession at the failure of physiotherapists to put their techniques on a sound scientific basis. Hopefully pressure to conduct research will come from within the profession as well as from without. With the introduction of a post-graduate diploma in physiotherapy and the establishment of a College of Paramedical Studies in N.S.W. there are likely to be more physiotherapists graduating with a deeper appreciation of the relevance of basic medical science to clinical techniques.

However an understanding of basic medical science is not the same thing as a knowledge of research methods. This paper is an attempt by two psychologists with experience in applied research to highlight what might be some of the problems in conducting research into the effects of physiotherapy treatments and to suggest some practical ways in which these problems could be solved.

Research is often regarded as being either an exciting and stimulating activity that is infinitely more attractive than actually doing something, or else as a somewhat mysterious activity to be regarded with awe as beyond the reach of the ordinary practitioner without highly specialised knowledge and training. Both of these attitudes are unfortunate, as they lead either to research workers denigrating the practice of a profession as a lesser art, or to practitioners never undertaking their own research.

Research can be exciting and challenging, but so can professional practice, and it is often as routine, exacting, and painstaking as professional practice. It requires special skills, but these are not necessarily of a higher order than the skills required for the practice of a profession. Ideally there should be a fruitful interchange between research and professional practice.

The most important step in any research is to define the problem correctly and to ask the right question. This should take place before a study is designed and before any data are gathered. If you do not ask the right questions, the chances of getting usable results are minimal, and the chances of using inappropriate and poorly understood strategies are high. So the first technique that any research worker must learn is that of asking the right questions. There is probably some intuition involved in this, and certainly many of the

[1] Based on an address given to the teaching staff of the New South Wales School of Physiotherapy, October 1972. Received March 1973.

most interesting connections between what were previously thought to be unrelated phenomena have been the result of flashes of insight. However there is no substitute for Pasteur's dictum that "Fortune favours the prepared mind" and someone whose knowledge of their field is wide and scholarly is more likely to be in a position to ask fortuitous questions than is someone whose professional knowledge is superficial. Another advantage of a thorough knowledge of the literature of your own field is that it prevents you from repeating past mistakes and unnecessarily duplicating the work of others.

What sorts of questions can physiotherapists most profitably ask about their field? Many questions why certain treatments have certain physiological effects, about the psychological and sociological correlates of rehabilitation, about basic neuromuscular and skeletal functions, are of vital concern to a physiotherapist, but they are perhaps more the province of interdisciplinary teams containing physiologists, psychologists, sociologists, engineers, and physiotherapists than they are of physiotherapists alone.

It is proposed that physiotherapists can most usefully perform their own research if they confine themselves to applied research with a pragmatic approach, if they ask themselves questions about whether, and under what circumstances, treatments are effective. This is not to say that they should not be involved in, and concerned with, basic research into why treatments are effective and what the rehabilitation process is. But it is unlikely that their training fits them for initiating such basic research projects, and the problems facing them are reduced to more manageable proportions if questions are asked within a more confined area.

Within this area, how should questions be asked? If the problem is posed as "What are the effects of physiotherapy treatments?" or even as "How effective is treatment X?" it is not readily amenable to solution. A question in this form does not suggest a ready line of attack, it is too broad and general to be of much use. By breaking the large problems down into a set of smaller, more precisely defined problems, questions more amenable to solution can be asked. Compare, for instance, the form of the following questions to the form of the preceding questions.

"Is treatment X more effective than treatment Y with condition Z?"

"Is treatment X more effective with condition Y than with condition Z?"

"Does treatment X have effect Y but not effect Z?"

"How does physiotherapy treatment X interact with drug treatment Y in condition Z?"

The basic purpose of scientific enquiry is to search for regularity, for orderly, relationships between variables in nature. If any relationship is to be discovered, it is necessary to separate the variables thought to be related from other variables not under consideration. It is necessary to screen out, or control, extraneous variables that could contaminate the relationship being investigated.

The most elementary model of scientific research assumes that an independent variable is related in a certain manner to a dependent variable, but more typically, a complex set of interacting independent variables are related to a complex set of dependent variables. Any effects of physiotherapy are probably the result of complex interactions between many variables, and one of the major tasks for a programme of research into physiotherapy treatments would be to develop both a classification of these variables and techniques for describing and controlling them so that they can be investigated in an orderly manner.

The relevant independent variables would appear to fall into four broad categories: (i) variables relating to treatments, (ii) variables relating to patients, (iii) variables relating to therapists, and (iv) variables relating to conditions. As we are not physiotherapists we cannot supply a complete taxonomy of relevant independent variables. However the following list could give some idea of the type of breakdown of independent variables that could be considered.

(i) Treatment variables:
- —type
- —duration
- —intensity
- —consistency
- —other concurrent medical treatment

(ii) Patient variables:
- —age
- —sex
- —prior medical history
- —family support
- —mobility
- —motivation

(iii) Therapist variables:
- —age
- —sex
- —experience
- —employing institution
- —competence
- —personality
- —professional attitudes

(iv) Condition variables:
- —type
- —severity
- —location
- —other concurrent injuries
- —time between onset and treatment.

There are three main reasons for exercising experimental control over independent variables, or determiners. These are (i) to isolate variables so that their effects are either ruled out or kept constant, (ii) to achieve changes in magnitude in variables so that we can determine not only whether variables have an effect, but how much of an effect they have and (iii) to achieve quantitative evaluation, so that numerical values can be attached to the extent of any discovered relationship.

Experimental controls normally fall into one of three categories: control by manipulation of experimental conditions, control by selection, and control by statistical techniques.

Direct physical manipulation of the determiner itself or of the immediate conditions that give rise to the determiner is one of the most precise methods of experimental control and it is most typically found in laboratory conditions and in many of the physical sciences. In the behavioural and medical sciences it is often either undesirable, unethical, difficult to achieve, or impossible to achieve. It would be difficult deliberately to assign certain therapists to one treatment and other therapists to another in order to control for inter-therapist differences. It would be unethical to deliberately refuse patients treatment or give them placebo treatments in order to investigate the effect of treatment versus non treatment. It would be impossible to deliberately manipulate a patient's weight, age, or prior medical history in order to investigate the effect of varying these parameters. So in all likelihood a programme of research into the effects of physiotherapy treatments would need to look at other techniques of control to isolate and evaluate variables of interest.

Statistical techniques of control are particularly appropriate in situations where many variables are acting together to determine an outcome and in which these variables are not amenable to direct physical manipulation. They are particularly appropriate in "real life", as opposed to laboratory, situations where direct physical manipulation is often impossible. Statistical controls enable the experimenter not only to isolate the effects of variables, but to estimate the relative importance of variables, and to examine the manner in which several variables interact. Statistical control is achieved not by manipulating attributes themselves, but by manipulating the numerical values that can be assigned to attributes. It assumes therefore that these attributes can actually be measured, as opposed to merely ordered or classified, and it is possible that much of a research programme into the effects of physiotherapy treatments could be devoted to developing techniques of measuring, or assigning numerical values to variables of interest.

There are basically three levels of measurement; categorical, ordinal, and linear. The measurement of height provides a simple illustration of the differences between the three. The simplest form of measurement is obtained when objects can only be placed into categories, for instance short or tall. The next level of measurement is obtained when objects can be put into rank order by comparing one to the other on the attribute under consideration. For instance a set of objects could be ranked in height from the tallest to the shortest. The highest form of measurement is ob-

tained when numerical units are assigned to the attribute in question and these units can be manipulated algebraically. For instance 5′ 6″ high, 3 metres high and so on. (Numerical values such as first, second, fifth cannot be manipulated in the same way as units such as one, two, and five).

With all forms of measurement it is essential that the attribute under consideration be clearly and unambiguously defined. "Weather", for example is not by itself able to be measured in a linear sense, but the attributes of which it consists, rainfall, temperature, air pressure and so on, can be. Similarly although "health" cannot be assigned numerically values, some of its attributes such as blood pressure and pulse rate can have numerical values assigned to them.

An example of the use of statistical techniques of control is provided from the field of aptitude testing. It is commonly found that, up to a certain point in adolescence, scores on most aptitude tests increase with age, with the rate of increase varying according to the aptitude being measured. In order to construct tables that enable a child's score to be assessed against the average performance of those of his own age, the rate of this increase for the test under consideration must be determined. However when unselected samples of school children are gathered, the relationship between test score and age is usually contaminated by an uncontrolled intelligence factor. If the older children in the sample are duller, scores appear to decrease with age (as most aptitude tests have an intelligence component). If the older children are brighter, scores on the test will appear to increase with age at a rate greater than the true increase.

Obviously in this case the subjects' intelligence cannot be physically manipulated. It could be controlled by careful selection methods, but statistical controls provide a quicker and easier method of obtaining the same result. By statistical manipulation of the subjects' test score, age, and intelligence it is possible, using a technique known as partial correlation, to remove the contaminating influence of intelligence from the relationship between test score and age, and so arrive at the true underlying rate at which test score increases with age.

Although most physiotherapists would not be trained in statistical methods, there is no reason why they could not co-opt the services of a competent statistician to instruct them on the use of techniques such as partial correlation, analysis of variance, and analysis of covariance.

As direct physical manipulation would often be difficult or impossible to achieve, and as statistical controls could be outside the training of many, it is likely that any programme of research into the effects of physiotherapy treatments would initially concentrate on selection as a technique of experimental control.

Control by selection is really an indirect form of control by manipulation. It has some problems in that it often makes it more difficult to evaluate the effects of variables using this technique, but it is an excellent way of isolating variables and it is a fairly easy, but nevertheless rigorous, technique of control for those lacking statistical training. If the number of variables that one wishes to control by selection is large, problems can sometimes arise in obtaining sufficient numbers of cases for results to be meaningful. For instance it might be difficult to obtain large numbers of patients all of whom are suffering from exactly the same type of muscular disorder, all of whom are receiving identical concurrent medical treatments, and of whom half have received one type of physiotherapy treatment and half another. However, the problem is not insuperable. One way of dealing with it is to use statistical techniques designed for small sample sizes when analysing your results. Another way of dealing with it is to increase your sample size and assume that variations on the relevant variables cancel out in their effects. For instance, in a study of the effect of treatment X versus treatment Y, you might feel that the age of the patients needed to be controlled. It might be difficult to select enough patients so that those receiving each treatment were all of the same age. So instead you could increase your sample size so that there were large numbers of patients of all ages in both groups, and, as long as the mean ages were comparable, you could probably assume that any effects due to age had been randomised, or cancelled out within each group. Similarly, in the same sort of situation, if treatment X was

given by only one therapist, and treatment Y by only one, you could be open to the charge that it was not the treatment but the competence of the therapist that had the effect. So you could control for this by having many therapists give each treatment and assume that differences in competence cancelled each other out. Of course the variables that you have randomised would still be having some effect, but it is possible to sort out by statistical means whether the effect due to the treatments is sufficient to outweigh these other sources of variation.

Another way of overcoming the problem of small sample size caused by selection is to use records of past treatments rather than rely only on cases immediately at hand. There can be problems here, for the quality of control that can be achieved is directly conditioned by the completeness and accuracy of the records that you are using. Most medical or other public records are designed to be case histories. They are not designed to be data for research, and if you are interested in using records for research, it could be advisable to set up a separate record-keeping system that documents all of the variables that are relevant expressed in a standard format that you have designed to be of most use to you.

We have said that one of the major problems facing a programme of research into the effects of physiotherapy treatments would be to develop techniques for controlling independent variables so that they can be investigated in an orderly manner, and we have briefly described some techniques of experimental control that can be considered. In doing so we have touched on what we consider to be the second major problem facing a research programme into the effects of physiotherapy treatments, and this is the problem of developing techniques for rigorously classifying, describing, and measuring both independent variables (or determiners) and dependent variables.

We have already outlined a possible scheme for classifying independent variables. Describing and measuring them in some cases is a simple task, but in other cases it is not. A patient's age and weight are easy to assess, and presumably standard techniques exist, or could easily be developed, for precisely measuring things such as balance, muscular strength, aerodynamic capacity, and tissue growth.

But variables such as mobility, independence, patient motivation, condition severity, and skill are not so apparently reducible to objective physical measures. In many cases it would be necessary to consider whether these variables can be measured at all. If they are not amenable to measurement in the strict sense, techniques for either classifying them precisely or putting them in rank order would need to be developed. For instance condition severity probably cannot be expressed in terms of numerical units that can be algebraically manipulated. But precise and standardised criteria for classifying conditions as "light", "moderate" or "severe" can be developed, as can techniques of ranking patients from high to low according to the severity of their conditions. The question of what degree of measurement you can assign to a variable is an important one, as it will determine the way you design a study, the technique you use to analyse your results, and what you can say about your results when you get them.

It is just as important to give thought to your dependent variables. It would be obvious that vague statements such as "All 32 patients left the hospital fully independent and able to walk safely alone" cannot be regarded as expressing meaningful relationships between independent and dependent variables. Just as there are many independent variables involved in influencing physiotherapy treatments, so too are there many dependent variables or effects that result from physiotherapy treatments, and you might well have more than one dependent variable in many studies. Some of these dependent variables are easy to define and measure, but the larger the behavioural units you are dealing with the more thought you will need to give to reducing these to an objectively measurable form.

One fairly obvious point which is sometimes forgotten is that you must measure your dependent variable both before applying treatment and after if you are to assess the extent of an effect. It is not sufficient to assess the state of your dependent variable only after treatment and presume an effect from this. Of course if you are going to assess your dependent variables before treatment is commenced,

you are going to need a special sort of record-keeping system and an administrative organisation that ensures that these desired measurements are made. The sorts of dependent variables that you would be dealing with probably fall into three groups: (i) physiological variables such as tissue growth, aerodynamic capacity, muscle tremor, and blood pressure, (ii) patient behaviour variables such as mobility, self care, and the ability to perform certain tasks (stretch, reach, grasp, *etc.*) and (iii) patient attitude variables such as increased interest in others, improved motivation, and increased general well being.

In the early stages of a research programme you would probably find it easier to concentrate on the first set of variables. Techniques for precisely describing and/or measuring the second group could well exist already, but if they do not they should not be too difficult to develop. The third group is quite tricky and you would probably need the assistance of either a clinical or a social psychologist to develop usable scales, as you would to assess independent variables such as patient motivation, and to assess the effect of patient/therapist relationships. The whole question of whether the value of therapy lies in the physical effects produced by treatments or in the psychological effects produced by a fairly intense patient/therapist relationship is not an easy one to tackle, but, as we mentioned earlier, it is probably more the province of interdisciplinary teams of investigators than of physiotherapists by themselves.

While we are on the question of the psychological effects involved in therapy, we should perhaps mention an important effect that should be controlled for in the organisation of any experimental procedure. You are probably all familiar with Heisenberg's dictum that the act of observation changes the event being observed. This is particularly the case when people are the units being observed, and a lot of recent work in psychology has shown that an experimenter's expectations, his personal involvement in the outcome of research, can unwittingly, through the use of subtle cues and reinforcers, influence the outcome of an experiment, independently of the other variables under investigation, so that the results are in the expected direction.

So it is probably not a good idea to conduct research into your own treatments, not because you will cook the results, but because your own involvement makes you less objective. The best way of organising a research project would be for the person organising the investigation not actually to conduct the treatments, for the therapists carrying out the treatments either not to know that they are involved in a research programme or to know as little as possible about its aims and purposes, and for patients, certainly, not to know that they are part of a research programme.

One final point which we have not discussed so far is how you analyse your results. As this is not meant to be a lecture on statistical methods we are not going to discuss it in detail. All we will say is that if you have designed your study well, exercised proper experimental controls, and used precisely defined and or measured independent and dependent variables, it is not difficult to bring in a statistician at the final stages to give you a hand. However, if your experiment is poorly designed and your data is a mess, even the best statistician won't be much use, so it could be advisable to check with someone who has statistical training before you actually collect your data just to make sure that it is amenable to statistical analysis and that it will give you the answers that you want.